https://doi.org/10.24867/GRID-2022-p47

EDIBLE FILM PRODUCTION WITH ALOE VERA EXTRACT AND ITS PRINTABILITY

Hatice BİRTANE [1], Aslı BEYLER ÇİĞİL [2]
[1]Marmara University, Faculty of Arts and Sciences, Department of Chemistry, Goztepe, İstanbul, Turkey
[2]Amasya University, Technical Sciences Vocational School, Department of Chemistry and Chemical Process Technology, Amasya, Turkey

Abstract: *The main concern with protecting fruits and vegetables from bacterial infection and growth is ensuring product quality and safety. Hydroxyethyl cellulose, with –OH in the natural cellulose molecule substituted by a hydroxyethyl group, has been widely used in oil exploitation, coating, medicine, food and polymerization process. It is nontoxic and low-cost. Aloe vera is a well-known herbal plant that is used for its therapeutic properties. The gel extracted from Aloe vera plants contains a variety of biologically active compounds, phenolic contents, and minerals. In this study, the edible films containing different proportions of aloe vera and hydroxyl ethyl cellulose were prepared. The structural and antibacterial properties of the obtained edible films were examined. The obtained films were printed with inkjet. Color and adhesion properties of printed samples were determined and it was observed that the edible films showed antibacterial properties.*

Key words: Edible film, hydroxyethyl cellulose, aloe vera, printability

1. INTRODUCTION

The main concern with protecting fruits and vegetables from bacterial infection and growth is ensuring product quality and safety. Edible films and coatings, such as wax on various fruits, have been used for centuries in order to ensure product quality and safety. Edible films are generally prepared from proteins, polysaccharides, lipids and their combinations with some additional food grade additives (Maan et al., 2021; Cheng et al., 2022). Various natural polysaccharides such as cellulose, chitosan, starch, pectin, alginate, gums, agar, dextran are widely used as edible films due to their performance in extending the shelf life of different food products. Edible film, when applied to a solid food surface, represents an edible primary packaging due to its direct contact with the food surface (Han, 2014; Galus & Kadzińska, 2015; Lin et al., 2022). Although this is not a new concept; however, current research focuses on developing active food packaging using new compounds derived from various herbal plants that can offer more functionality than just providing barrier and mechanical strength. Today, herbal plants in edible film use have become even more common. The aloe vera has been used for healthy applications and other fields for example; beauty, medicinal and skin care properties (Mary et al., 2022; Mahajan et al., 2022). Numerous substances, including minerals, enzymes, hormones, and carbohydrates, can be found in aloe vera gel extract. Aloe vera and its bioactive components have so been researched to learn more about its exciting prospective applications in the field of medicine (Hadi et al., 2022; Hou et al., 2021; Farid et al., 2022). Aloe vera is a botanical with great medicinal value that has been well researched for use in food, medicine, and cosmetics (Passafiume et al., 2020). It is the most well-known species of aloe and a member of the Aloaceae family (Vieira et al., 2016). It is a xerophytic plant that is succulent and well adapted to growing in dry climates. Soft, slick tissues including parenchyma cells make up aloe vera gel. It is a clear object and has a complex composition; In addition to carbohydrates, proteins, fiber, soluble sugars, vitamins, minerals, amino acids, organic acids, and phenolic compounds, it also contains a variety of bioactive substances. Due to its success in prolonging the shelf life of numerous perishable food goods during the past 10 years, it has attracted a lot of attention as an edible film. Aloe vera gel films are a great example of natural and active packaging because of their barrier qualities as well as their antioxidant and antibacterial potential.

In this study, aloe vera containing edible films was prepared and then we investigate the antimicrobial activity of the prepared films and its printability.

2. METHODS

2.1 The preparation of aloe vera gel from aloe vera plant

Leaves of aloe vera were cleaned by distilled water. The gel was collected from the leaves and then was stirred vigorously and aloe vera gel was prepared to use at edible film preparation (Figure 1).

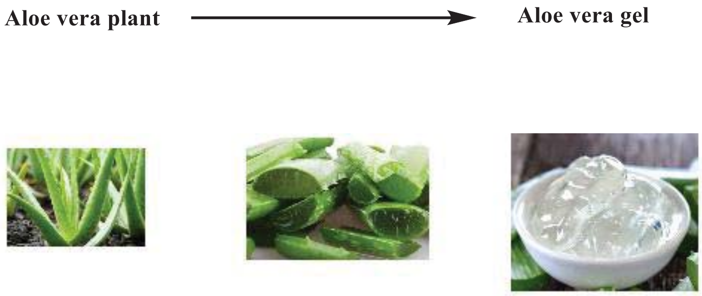


Figure 1: Preparation of aloe vera gel

2.2 The preparation of the edible films

%1 wt hydroxyl ethylcellulose (HEC) solution in distilled water is prepared. F0 formulation is edible film without aloe vera. F0 is prepared with hydroxyl ethylcellulose. For F1 formulation, 1 g HEC and 0,01 g aloe vera are mixed and then the mixture was poured into Teflon molds and dried in a vacuum oven at 60°C. The formulation table of the prepared edible films was given in Table 1.

Table 1: Formulation Table

	HEC (g)	Aloe vera (g)
F0	1	-
F1	1	0,01
F3	1	0,03
F5	1	0,05

ATR–FTIR spectrum was recorded on Perkin Elmer Spectrum100 ATR–FTIR spectrophotometer. Shimadzu 310 UV–Vis–NIR spectrometer was used to assess the transmission percentage of the edible films. The wettability of edible films was determined using the contact angle with the sessile water droplet method. The characteristics of printed surfaces were determined with contact angle (TAPPI T458). Distilled water was used as standard wetting fluid in a Pocket Goniometer Model PG-X, (FIBRO Systems AB, Sweden), which was measured as a function of time. The program is of version 3.4. Images of water droplets were then recorded by using a CCD video camera. Surface energies were calculated on the contact angle by ASTM D5946-17 standard test method.
The obtained films printed as a background with the BENTSAI BTHH 6105 handheld thermal inkjet printing machine. The colors of unprinted and the printed films were measured by X-Rite eXact portable spectrophotometer, gloss measurements were measured with BYK Gardner gloss measuring device at an angle of 60° and 75°. Color differences were calculated according to the CIELab (2000) technique.

3. RESULTS

3.1 ATR-FTIR

The produced edible films ATL- FTIR spectra is shown in Figure 2. The prepared edible films' ATR-FTIR spectra in comparison to HEC is shown in Figure 2. The spectra of the edible films' absorption bands resembled those of the F0 formulation. In the literature, stress vibrations of C-H have been linked to the peaks at 2924 and 2874 cm^{-1} in the spectra of HEC (Şen et al., 2018). Additionally, at 3400 and 1061 cm-^{1,}

respectively, the vibration bands associated with hydroxyl groups and -C-OH bonds could be detected. This peak, which was observed at 1061 cm^{-1}, was observed to have significantly lowered when compared to the edible films. (Beyler Çiğil et al., 2022).

Accordingly, it can be argued that the edible films were successfully prepared. The ATR-FTIR spectra of the prepared antibacterial coatings with nanosilver/hydroxyethyl cellulose/polyacrylic acid/sorbitol in another our study were similar to those in the present study (Beyler Çiğil et al., 2022).

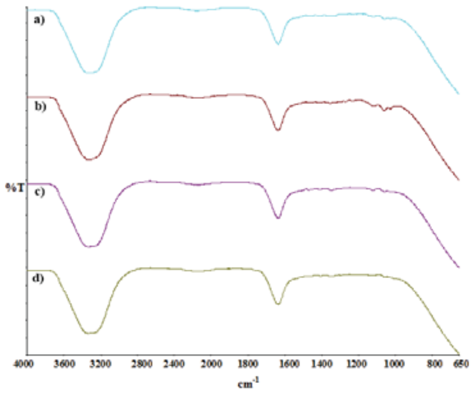
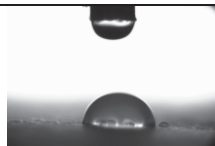
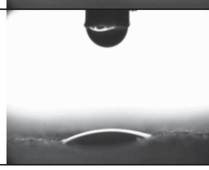


Figure 2: ATR-FTIR spectra of a) F0, b) F1, c) F2 and d) F3 formulations

3.2 Contact Angle

The contact angle is measured in the liquid where the liquid vapor interface meets a solid surface. Surface roughness has a strong influence on the contact angle and wettability of a surface (Birtane et al., 2019). The contact angle of edible films containing aloe vera decreases with increasing aloe vera content. Contact angle images of edible films are given in Table 2. The contact angle values were slightly decreased with the presence of aloe vera in edible films. This may be related to the hydrophilic structures in aloe vera. Similar results have been reported in the literature (Pereira et al., 2013).

Table 2: Total surface energy and contact angle values of all papers according to ASTM D5946 method

Paper samples	Total surface energy (mJ/m^2)	Contact Angle with water	Images
Base paper	42.3	62.8	
F0	54.9	38.4	
F1	51.2	28.1	
F3	55.7	26.0	
F5	58.0	19.6	

3.3 Printability Properties

Table 3: Color characteristics and glosses of coated papers

	L	A	b	Delta E	Gloss
Base paper	91.76	2.43	-10.71		5.8
F0 film's	89.13	2.02	-9.54	1.87	13.0
F1 Film's	90.03	2.03	-9.52	1.41	13.4
F3 Film's	90.55	2.13	-9.85	1.00	13.6
F5 Film's	91.92	2.36	-10.08	0.45	14.2

In order to determine the color and gloss of the prepared film, the measurements were made on white paper and the results are given in Table 4. When Table 4 is examined, it is seen that the change in L and b values, in which the color of the film without aloe vera, changes the most. The change in b value indicates that the color has shifted slightly towards yellow. With the addition of aloe vera, the color shift to yellow with a slight blue/green glow, which is the color of aloe vera itself, is reduced. And accordingly, a decrease in delta e, which is the color change value, was observed. When all coatings are examined, the delta e difference is below 2 and it is not possible to distinguish this difference with the human eye. When the gloss values were examined, it was determined that the gloss of the white paper used as the background was 2 times lower than the films. The fact that the surface of the white office paper is rough and the surface of the produced film is smooth revealed this result. In addition, an increase in gloss was observed as the amount of aloe vera added to the formulation increased.

Table 4: Color characteristics and glosses of printed papers

	L	a	B	Delta E	Gloss
Base paper print	53.97	-26.71	-48.63		6.7
F0 Film's Print	52.99	-26.08	-48.30	0.85	21.6
F1 Film's Print	53.90	-26.65	-47.49	0.78	22.1
F3 Film's Print	53.90	-26.11	-47.14	0.70	22.7
F5 Film's Print	54.22	-26.61	-46.16	1.01	23.3

Cyan ink was applied on the films produced with a thermal inkjet printer and the color and gloss values of the prints were measured on white office paper. Obtained results are given in Table 4. When the results are examined, it is seen that the color changes are lower than the unprinted films compared to the base paper (Only the F5 formation delta E difference is higher). This is because the cyan ink tolerates yellowing. Thus, yellow glows by the pigment were reduced and the color became closer to the base paper. The color differences of all prints are below the detection limit of the human eye, that is, all prints are seen in the same color as the main paper. Gloss values, on the other hand, increased approximately 2 times compared to the base films. This is due to the gloss of the resin in the printed ink. Parallel to the unprinted films, an increase in the gloss value was observed as the amount of aloe vera increased.

3.4 Optical properties

The transmission percentage of the prepared edible films was characterized by UV–Vis spectroscopy. The UV–Vis transmission spectra of the edible films are given in Figure 3. It was found that between 750 and 300 nm, The optical transmittance of edible films decreased slightly with increasing aloe vera content. But it can be seen that the decrease in the optical transmittance in the visible region is very low. This situation can be attributed to the homogeneous dispersion of aloe vera in hydroxylethyl cellulose.

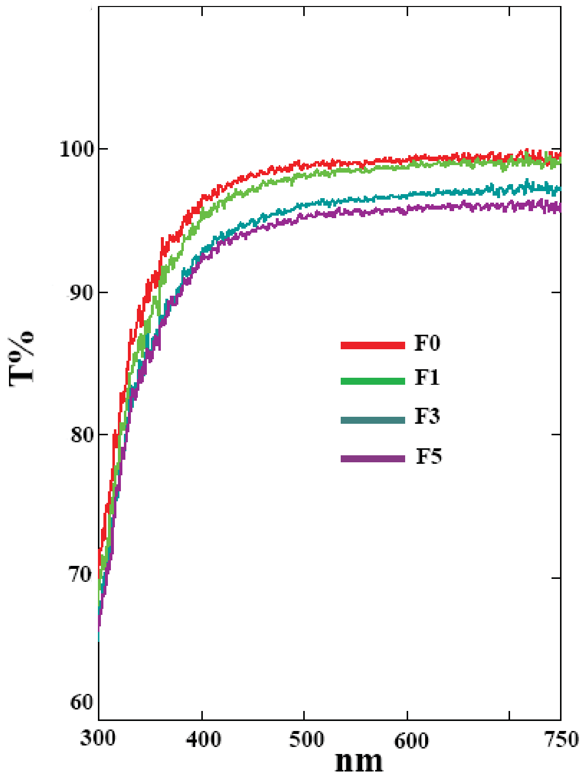


Figure 3: UV–Vis transmittance of edible films

3.5 Antimicrobial activity of Aloe vera containing coatings

Antimicrobial films made with aloe vera were tested against Gram-positive pathogenic bacteria like *S. aureus* and Gram-negative pathogenic bacteria like *E. coli*. Table 5 displays the widths of the samples' inhibition zones. It was noted that *S. aureus* and *E. coli* grew uniformly in every area of the petri plates used for the control samples. It was discovered that all edible films that had been made had inhibitory effects on *S. aureus* and *E. coli*. Aloe vera's inherent structure is what gives edible films containing the plant its antibacterial properties. Both bacterial species' antibacterial qualities improved as aloe vera concentration increased.

Table 5: Antimicrobial activity of the edible films against E. coli and S. aureus (inhibition zone diameter in centimeter)

Sample	*E. Coli*	*S. Aerus*
F0	1.4	1.1
F1	1.5	1.2
F3	1.8	1.5
F5	1.8	1.5

4. CONCLUSIONS

In the present study, the edible and environmentally friendly antibacterial edible films were prepared with HEC and aloe vera. The ATR-FTIR results showed that the coatings were successfully prepared. Also, it was observed that aloe vera is covalently bound to the surface of hydroxylethyl cellulose. Moreover, it was observed that aloe vera significantly increased the antibacterial behavior of the edible films. The zone of inhibition was measured for both *E. coli* and *S. aureus* as 14 and 11 mm respectively. In a general evaluation, it was seen that the edible antimicrobial films were successfully obtained and can be used in the printing industry.

7. REFERENCES

Beyler Çiğil, A., Şen, F., Birtane, H. & Kahraman, M. V. (2022) Covalently bonded nanosilver-hydroxyethyl cellulose/polyacrylic acid/sorbitol hybrid matrix: thermal, morphological and antibacterial properties. *Polymer Bulletin*. Available from: doi:10.1007/s00289-022-04089-2

Birtane, H., Esmer, K., Madakbaş, S. & Kahraman, M. V. (2019) Structural and dielectric properties of POSS reinforced polyimide nanocomposites. *Journal of Macromolecular Science, Part A*. 56 (3), 245 - 252. Available from: doi:10.1080/10601325.2019.1565546

Cheng, J., Li, Z., Wang, J., Zhu, Z., Yi, J., Chen, B. & Cui, L. (2022) Structural characteristics of pea protein isolate (PPI) modified by high-pressure homogenization and its relation to the packaging properties of PPI edible film. *Food Chemistry.* 388, 132974 - 13283. Available from: doi:10.1016/j.foodchem.2022.132974

Farid, A., Haridyy, H., Ashraf, S., Ahmed, S. & Safwat, G. (2022) Aloe vera gel as a stimulant for mesenchymal stem cells differentiation and a natural therapy for radiation induced liver damage. *Journal of Radiation Research and Applied Sciences*. 15 (3), 270 - 278. Available from: doi:10.1016/j.jrras.2022.07.010

Galus, S. & Kadzińska, J. (2015) Food applications of emulsion-based edible films and coatings. *Trends in Food Science & Technology*. 45 (2), 273 - 283. Available from: doi:10.1016/j.tifs.2015.07.011

Hadi, A., Nawab, A., Alam F. & Zehra, K. (2022) Alginate/aloe vera films reinforced with tragacanth gum. *Food Chemistry: Molecular Sciences*. 4, 100105. Available from: doi:10.1016/j.fochms.2022.100105

Han, J. H. (2014) Edible Films and Coatings: A Review. *Innovations in Food Packaging.* 213 - 255. Available from: doi:10.1016/B978-0-12-394601-0.00009-6

Hou, Y., Gao, Y., Wang, X., Zhang, Y., Li, J., Zhang, H. & Li, X. (2021) Alginate-aloe vera film contains zinc oxide nanoparticles with high degradability and biocompatibility on post-cesarean wounds. *Journal of Drug Delivery Science and Technology*. 66, 102631. Available from: doi:10.1016/j.jddst.2021.102631

Lin, L., Peng, S., Chang, Shi, C., Li, C., Hua, Z. & Cui, H. (2022) Preparation and characterization of cassava starch/sodium carboxymethyl cellulose edible film incorporating apple polyphenols. *International Journal of Biological Macromolecules*. 212, 155 - 164. Available from: doi:10.1016/j.ijbiomac.2022.05.121

Maan, A. A., Ahmed, Z. F. R., Khan, M. K. I., Riaz, A. & Nazir, A. (2021) Aloe vera gel, an excellent base material for edible films and coatings. *Trends in Food Science & Technology*. 116, 329 – 341. Available from: doi:10.1016/j.tifs.2021.07.035

Mahajan, K., Kumar, S., Bhat, Z. F., Singh, M., Bhat, H. F., Bhatti, M. A. & Bekhit, A. E. A. (2022) Aloe vera and carrageenan based edible film improves storage stability of ice-cream. *Applied Food Research*. 2 (1), 100128. Available from: doi:10.1016/j.afres.2022.100128

Mary, K. L., Manonmoni, J. V., Balan, A. M. R., Karthik, P. S. & Malliappan, S. P. (2022) Phytochemical assisted synthesis of Ni doped ZnO nanoparticles using aloe vera extract for enhanced photocatalytic and antibacterial activities. *Digest Journal of Nanomaterials and Biostructures*. 17 (2), 634 – 648. Available from: doi:10.15251/DJNB.2022.172.634

Passafiume, P., Gaglio, R., Sortino, G. & Farina, V. (2020) Effect of Three Different Aloe vera Gel-Based Edible Coatings on the Quality of Fresh-Cut "Hayward" Kiwifruits. *Foods*. 9 (7), 939. Available from: doi:10.3390/foods9070939

Pereira, R. F., Carvalho, A. Gil, M. H., Mendes, A. & Bártolo, P. J. (2013) Influence of Aloe vera on water absorption and enzymatic in vitro degradation of alginate hydrogel films. *Carbohydrate Polymers*. 98 (1), 311 - 320. Available from: doi:10.1016/j.carbpol.2013.05.076

Şen, F. & Kahraman, M. V. (2018) Preparation and characterization of hybrid cationic hydroxyethyl cellulose/sodium alginate polyelectrolyte antimicrobial films. *Polymers for Advanced Technologies*. 29, 1895 - 1901. Available from: doi:10.1002/pat.4298

Vieira, J. M., Flores-López, M. L., Rodríguez, D. J., Sousaa, M. C., Vicente, A. A. & Martins, J. T. (2016) Effect of chitosan–Aloe vera coating on postharvest quality of blueberry (Vaccinium corymbosum) fruit. *Postharvest Biology and Technology*. 116, 88 – 97. Available from: doi:10.1016/j.postharvbio.2016.01.011